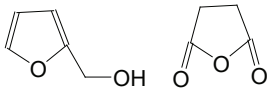
FR furan resin

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	furan resin	
IUPAC name	-	poly(furan-2,5-dimethylene)	
CAS name	-	2,5-furandione, polymer with 2-furanmethanol	
Acronym	-	FR	
CAS number	-	25054-13-1	
HISTORY			
Person to discover	-	Heberer, A J; Marshall, W R	Heberer, A J; Marshall, W R, US Patent 2,095,250, Glidden, Oct. 12, 1937.
Date	-	1937	
Details	-	synthetic coating composition	
SYNTHESIS			
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	98-00-0; 108-31-6	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	98.10; 98.06	
Method of synthesis	-	furan can be obtained by elecrochemical and chemical polymerization (details in references)	Gonzalez-Tejera, M J; Sanchez de la Blanca, E; Carrillo, I, Synthetic Metals, 158, 165-189, 2008; Rivero, G; Fasce, L A; Cere, S M; Manfredi, L B, Prog. Org. Coat., 77, 247-56, 2014.
Temperature of polymerization	°C	135	
Time of polymerization	h	4	
Catalyst	-	p-toluene sulfonic acid monohydrate (cure catalyst)	Kandola, B K; Ebdon, J R; Chowdhury, K P, Polymers, 7, 298-315, 2015.
Polydispersity, M_w/M_n	-	2.33	de Vergara, U L; Sarrionandia, M; Gondra, K; Aurrekoetxea, J, Thermochim. Acta, 581, 92-9, 2014.
STRUCTURE	-		
Crystallinity	%	10	Gok, A; Can, H K; Sari, B; Talu, M, Mater. Lett., 59, 80-84, 2005.
COMMERCIAL POLYMERS			
Some manufacturers	-	Sika; Transfurans Chemicals	
Trade names	-	Asplit; Furolite	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.18-1.22	
Color	-	brown	
pH		4.5-4.9	
Glass transition temperature	°C	252	Rivero, G; Fasce, L A; Cere, S M; Manfredi, L B, Prog. Org. Coat., 77, 247-56, 2014.
Maximum service temperature	°C	200	

PARAMETER	UNIT	VALUE	REFERENCES
Contact angle of water, 20°C	degree	66.8	Rivero, G; Fasce, L A; Cere, S M; Manfredi, L B, Prog. Org. Coat., 77, 247-56, 2014.
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	40-160 (40-70% glass fiber)	
Flexural strength	MPa	50-200 (40-70% glass fiber); 365 (carbon fiber)	
Flexural modulus	MPa	6,000-10,000 (40-70% glass fiber); 25,000 (carbon fiber)	
Charpy impact strength, unnotched, 23°C	kJ m^{-2}	10-50 (40-70% glass fiber)	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	good/poor	
Alcohols	-	good	
Alkalis	-	good	
Aliphatic hydrocarbons	-	good	
Aromatic hydrocarbons	-	good	
Esters	-	good	
Greases & oils	-	good	
Halogenated hydrocarbons	-	good	
Ketones	-	good	
Good solvent	-	hot $HClO_4$	
Non-solvent	-	NMP, THF, DMR, $CHCl_3$, CH_3COOH, CCl_4	Li, X-G; Kang, Y; Huang, M-R, J. Comb. Chem., 8, 670-78, 2006.
FLAMMABILITY			
Ignition temperature	°C	104; 65 (furfuryl alcohol)	
Time to ignition	s	98	Monti, M; Hoydonckx, H; Stappers, F; Camino, G, Eur. Polym. J., 67, 561-69, 2015.
Autoignition temperature	°C	490 (furfuryl alcohol)	
Limiting oxygen index	% O_2	22.7-23.1	Kandola, B K; Ebdon, J R; Chowdhury, K P, Polymers, 7, 298-315, 2015.
Peak heat release	kW m^{-2}	682	Monti, M; Hoydonckx, H; Stappers, F; Camino, G, Eur. Polym. J., 67, 561-69, 2015.
Total heat release	MJ m^{-2}	30.9-39	Kandola, B K; Ebdon, J R; Chowdhury, K P, Polymers, 7, 298-315, 2015.
Char at 500°C	%	38-44.2	Kandola, B K; Ebdon, J R; Chowdhury, K P, Polymers, 7, 298-315, 2015.
Effective heat of combustion	MJ kg^{-1}	15.3	Monti, M; Hoydonckx, H; Stappers, F; Camino, G, Eur. Polym. J., 67, 561-69, 2015.
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	2/2/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP (furfural has been shown to cause cancer in laboratory animals)	
TLV, ACGIH	ppm	10 (furfuryl alcohol)	

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PARAMETER	UNIT	VALUE	REFERENCES
NIOSH	ppm	10 (furfuryl alcohol)	
OSHA	ppm	50 (furfuryl alcohol)	
Oral rat, LD_{50}	mg kg^{-1}	177 (furfuryl alcohol)	
Skin rabbit, LD_{50}	mg kg^{-1}	400 (furfuryl alcohol)	
PROCESSING			
Typical processing methods	-	BMC, compounding, curing, filament winding, molding, prepreg, pultrusion, RTM, SMC, spraying	
activation energy of curing	kJ mol^{-1}	78.24-79.83	de Vergara, U L; Sarrionandia, M; Gondra, K; Aurrekoetxea, J, Thermochim. Acta, 581, 92-9, 2014
Additives used in final products	-	Fillers: carbon fiber, glass fiber, mineral fillers, natural fibers;	
Applications	-	brake linings, composites, foundry, mortar cements, refractory materials, sand and soil consolidation, wood modification	
Outstanding properties	-	dimensional stability, hardness, resistance to fungal attack, stiffness	
BLENDS			
Suitable polymers	-	PEDOT, unsaturate polyester	Kandola, B K; Ebdon, J R; Chowdhury, K P, Polymers, 7, 298-315, 2015.
ANALYSIS			
NMR (chemical shifts)	ppm	3-3.4 (H_2O), 3.7 ($–CH_2–OH$), 3.9-4 ($–CH_2–$) and many more for ^{1}H and ^{13}C	de Vergara, U L; Sarrionandia, M; Gondra, K; Aurrekoetxea, J, Thermochim. Acta, 581, 92-9, 2014